Application Report
SWRA588B–January 2018–Revised December 2018

SimpleLink™ CC1312R LaunchPad™ for 868 MHz/915 MHz Bands LAUNCHXL-CC1312R1

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ABSTRACT

The LAUNCHXL-CC1312R1 Launchpad (SimpleLink CC1312R Wireless MCU Launchpad for 868 MHz/915 MHz frequency bands) development kit [16] with Sub-1GHz Radio, which offers long range connectivity, combined with a 32-bit Arm® Cortex®-M4F processor on a single chip.The Launchpad is designed to operate in both 868 MHz ISM band for Europe and 915 MHz ISM band for USA with a single board without any modification to the board assembly. The Launchpad is equipped with a broadband integrated PCB trace antenna, which covers both 868 MHz and 915 MHz frequency bands. The Launchpad is also equipped with the SMA connector for testing purpose and also to facilitate an external antenna connection.The Launchpad LAUNCHXL-CC1312R1 is shown in Figure 1 and Figure 2.

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Trademarks

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1 Introduction

The LAUNCHXL-CC1312R1 Launchpad (SimpleLink CC1312R Wireless MCU Launchpad for 868 MHz/915 MHz frequency bands) development kit [16] with Sub-1GHz Radio, which offers long range connectivity, combined with a 32-bit Arm Cortex-M4F processor on a single chip. The Launchpad is designed to operate in both 868 MHz ISM band for Europe and 915MHz ISM band for USA with a single board without any modification to the board assembly. The Launchpad is equipped with a broadband integrated PCB trace antenna, which covers both 868 MHz and 915 MHz frequency bands. The Launchpad is also equipped with the SMA connector for testing purpose and also to facilitate an external antenna connection. The LaunchPad LAUNCHXL-CC1312R1 is shown in Figure 1 and Figure 2.

The LAUNCHXL-CC1312R1 Launchpad [16] is suitable for systems targeting compliance with Worldwide Radio Frequency Regulations such as ETSI EN 300 220 for Europe, FCC CFR47 Part 15 for USA and other worldwide standards. For more details, see the I*SM-Band and Short Range Device Regulatory Compliance Overview* [10].

The LAUNCHXL-CC1312R1 LaunchPad is part of TI's SimpleLink MCU platform, offering a single development environment that delivers flexible hardware, software and tool options for customers developing wired and wireless applications. Save time and production cost by quickly prototyping your system with the LaunchPad kit's I/O connectors that allow for quick interfacing to a variety of evaluation modules (EVMs) and BoosterPack plug-in modules. Develop your Internet of Things (IoT) software application on the CC1312R LaunchPad kit using the SimpleLink CC13x2 software development kit (SDK) featuring: the TI 15.4 stack, RF driver, power management driver and multiple peripheral drivers. The SDK also includes several "getting started" software examples to kickstart your development. All software examples included in the SimpleLink CC13x2 SDK support the CC1312R LaunchPad kit, making writing your application easy. An overview of the software examples can be found on the product page [15].

The CC1312R is a member of the CC26x2 and CC13x2 family of cost-effective, ultra-low-power, 2.4 GHz and Sub-1 GHz RF devices. Very low active RF and microcontroller (MCU) current consumption, in addition to flexible low-power modes, provides excellent battery lifetime and allow long range operation on small coin-cell batteries and in energy-harvesting applications.

The CC1312R device combines a flexible, very low-power RF transceiver with a powerful 48-MHz Arm Cortex-M4F microcontroller in a platform supporting multiple physical layers and RF standards. A dedicated Radio Controller (Arm Cortex-M0) handles low-level RF protocol commands that are stored in ROM or RAM, thus ensuring ultra-low power and great flexibility. The low power consumption of the CC1312R device does not come at the expense of RF performance; the CC1312R device has excellent sensitivity and robustness (selectivity and blocking) performance.

The CC1312R device is a highly integrated, true single-chip solution incorporating a complete RF system and an on-chip DC-DC converter.

Sensors can be handled in a very low-power manner by a programmable, autonomous ultra-low power Sensor Controller CPU with 4kB SRAM for program and data. The Sensor Controller, with its fast wake-up and ultralow-power 2MHz mode is ideal to sample, buffer and process both analog and digital sensor data; thus the MCU system is able to maximize sleep time and reduce active power.

The CC1312R power and clock management and radio systems require specific configuration and handling by software to operate correctly, which has been implemented in the TI-RTOS. Texas Instruments™ (TI) recommends using this software framework for all application development on the device. The complete TI-RTOS and device drivers are offered in source code free of charge.

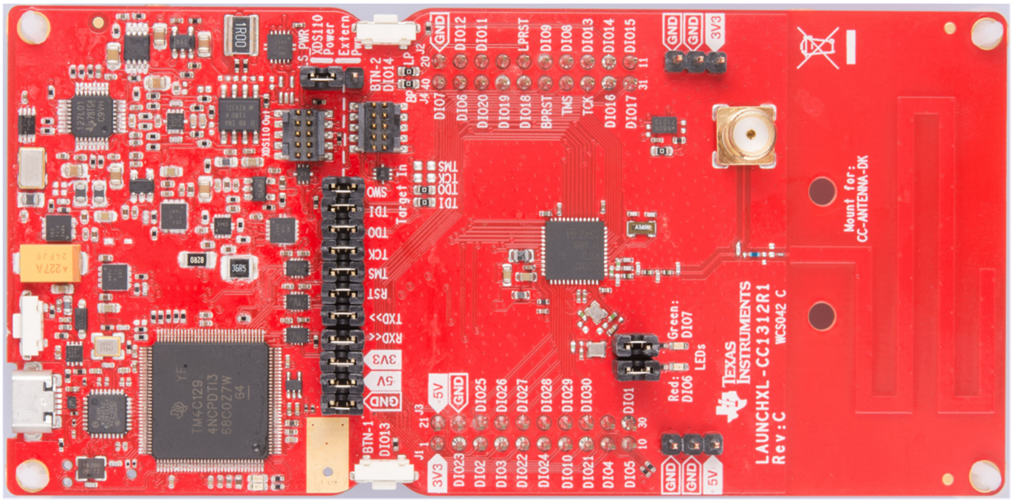

Figure 1. LAUNCHXL-CC1312R1 - Top side

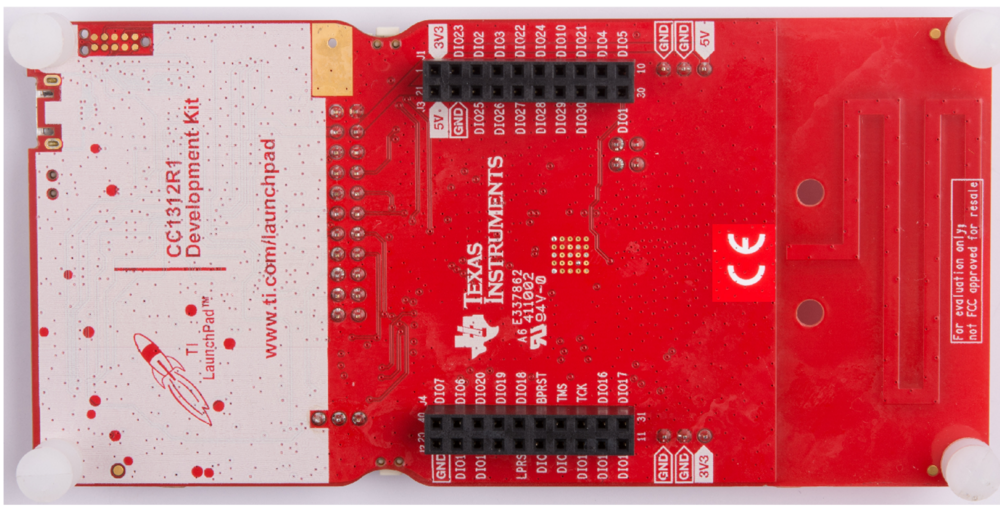

Figure 2. LAUNCHXL-CC1312R1 - Bottom side

1.1 Acronyms Used in This Document

Table 1. Acronyms and Description

Acronym	Description
AV	Average
BER	Bit Error Rate
BLE	Bluetooth low energy
BW	Bandwidth
DET	Detector
DEV	Deviation
EVM	Evaluation Module
FCC	Federal Communications Commission
ISM	Industrial, Scientific, and Medical Frequency Bands
LRM	Long Range Mode
PCB	Printed Circuit Board
PER	Packet Error Rate
RF	Radio Frequency
RSSI	Receive Signal Strength Indicator
RX	Receive, Receive Mode
SRS	SmartRF™ Studio
TX	Transmit, Transmit Mode

2 Absolute Maximum Ratings

The absolute maximum ratings and operating conditions listed in the CC1312R data sheet [1] must be followed at all times. Stress exceeding one or more of these limiting values may cause permanent damage to any of the devices.

3 Electrical Specifications

These specifications are valid only when using LAUNCHXL-CC1312R1 LaunchPad reference design [2] and the register settings recommended in SmartRF Studio [11]. For the detailed electrical specifications of the device, see the CC1312R data sheet [1].

3.1 Operating Conditions

The operating conditions are shown in Table 2.

Table 2. Operating Conditions

Parameter	Min	Max	Unit
Operating Frequency	868	868.6	MHz
	902	928	MHz
Operating Supply Voltage	4.0	5.5	V
Operating Supply Current at 5 V		250	mA
Operating Temperature	-20	+70	°C

3.2 Current Consumption

T_C = 25°C, CC1312R_VDD = 3.3 V, DC-DC enabled, if nothing else is stated. All parameters were measured on the LAUNCHXL-CC1312R1 reference design [2] with a 50 Ω load.

Table 3. Current Consumption

Parameter	Condition	Typical	Unit
Standby Current	Without USB Interface	0.03	mA
Standby Current	With USB Interface + SRS	2.3	mA
Receive Current at 868/915 MHz	Continuous mode	7.6	mA
Transmit Current at 868/915 MHz	At +14 dBm Setting	27.5	mA

3.3 Receive Parameters - 868 MHz

T_C = 25°C, CC1312R_VDD = 3.3 V, DC-DC enabled, f = 868 MHz, if nothing else is stated. All parameters were measured on the LAUNCHXL-CC1312R1 reference design [2] at an antenna connector with a 50 Ω load. An on-board PCB antenna was used in radiative measurements. Sensitivity limit is defined as 1% bit error rate (BER) with 3 bytes packet length.

Table 4. Receive Parameters – 868 MHz

Parameter	Condition	Typical	Unit
Sensitivity	50 kbps, 2 GFSK, DEV = 25 KHz, CHF = 98 KHz	-110.3	dBm
	SimpleLink Long Range Mode: 2.5 KBPS, 20 KSPS, 2-GFSK, Dev=5KHz, CHF = 38 KHz	-120.7	dBm
Saturation	Maximum input power level for 1% BER	+10	dBm
Blocking and Selectivity (1)	Wanted signal 3dB above sensitivity level , 50 kbps, 2-GFSK, DEV= 25 KHz, CHF = 87 kHz		dB
	±200 KHz from wanted signal	35, 34 (2)	
	±400 KHz from wanted signal	49, 47 (2)	
	±1 MHz from wanted signal	57, 56 (2)	
	±2 MHz from wanted signal	59, 58 (2)	
	±5 MHz from wanted signal	63, 63 (2)	
	±10 MHz from wanted signal	64, 64 (2)	
Rx Spurious emission	Conducted – 30 MHz to 13 GHz	<-98	dBm
	Radiated emissions measured according to ETSI EN 300 220		
	30 MHz to 1 GHz	<-57	
	1 GHz to 13 GHz	<-47	
RSSI dynamic range	Receive continuous mode.	95	dB
	Linear range from -115 dBm to -20 dBm		
RSSI Accuracy	Receive continuous mode.	±2	dB
	RSSI Offset = 0 dB		

(1) Numbers given as I/C dB.
(2) X/Y, where X is +N MHz and Y is -N MHz.

3.4 Transmit Parameters - 868 MHz

T_C = 25°C, CC1312R_VDD = 3.3V, DC-DC enabled, 868 MHz, if nothing else is stated. All parameters were measured on the LAUNCHXL-CC1312R1 reference design [2] at an antenna connector with a 50 Ω load. An on-board PCB antenna was used in radiative measurements.

Table 5. Transmit Parameters – 868 MHz

Parameter	Condition	Typical	Unit
Max output power	At +14 dBm setting	14.2	dBm
Tx output power	At +10dBm setting (Customers need to Limit their Tx Power setting to +10dBm to meet Maximum Power ERP defined by ETSI EN300 220-2 Standard)	10.1	dBm
Harmonic emission	At +14 dBm Setting		dBm
	Conducted 2nd harmonic	-48.5	
	Conducted 3nd harmonic	-52.5	
	Conducted 4th harmonic	-58.2	
	At +10 dBm setting		
	Conducted 2nd harmonic	-43.6	
	Conducted 3nd harmonic	-59.6	
	Conducted 4th harmonic	<-59.6	
Spurious emissions	At +14 dBm setting		dBm
	Conducted in ETSI Restricted bands		
	Conducted below 1 GHz	-49	
	Conducted above 1 GHz	-56	
	Radiated in ETSI Restricted bands		
	Radiated below 1 GHz	<-57	
	Radiated above 1 GHz	-54	

3.5 Receive Parameters - 915 MHz

T_C = 25°C, CC1312R_VDD = 3.3 V, DC-DC enabled, f = 915 MHz, if nothing else is stated. All parameters were measured on the LAUNCHXL-CC1312R1 reference design [2] at an antenna connector with a 50 Ω load. An on-board PCB antenna was used in radiative measurements. Sensitivity limit is defined as 1% bit error rate (BER) with 3 bytes packet length.

Table 6. Receive Parameters - 915 MHz

Parameter	Condition	Typical	Unit
Sensitivity	50 kbps, 2 GFSK, DEV = 25 KHz, CHF = 98 KHz	-110.2	dBm
	SimpleLink Long Range Mode: 2.5 KBPS, 20 KSPS, 2-GFSK, Dev=5KHz, CHF = 38 KHz	-119.7	dBm
Saturation	Maximum input power level for 1% BER	+10	dBm
Blocking and Selectivity (1)	Wanted signal 3dB above sensitivity level , 50 kbps, 2-GFSK, DEV= 25 KHz, CHF = 87 kHz		dB
	±200 KHz from wanted signal	35, 34 (2)	
	±400 KHz from wanted signal	48, 47 (2)	
	±1 MHz from wanted signal	57, 50 (2)	
	±2 MHz from wanted signal	59, 57 (2)	
	±5 MHz from wanted signal	64, 63 (2)	
	±10 MHz from wanted signal	65, 65 (2)	
Rx Spurious emission	Conducted – 30 MHz to 13 GHz	<-98	dBm
	Radiated emissions measured according to ETSI EN 300 220 (as this is more stringent than FCC part 15)		
	30 MHz to 1 GHz	<-57	
	1 GHz to 13 GHz	<-47	
RSSI dynamic range	Receive continuous mode.	95	dB
	Linear range from -115 dBm to -20 dBm		
RSSI Accuracy	Receive continuous mode.	±2	dB
	RSSI Offset = 0 dB		

(1) Numbers given as I/C dB.
(2) X/Y, where X is +N MHz and Y is -N MHz.

3.6 Transmit Parameters - 915 MHz

T_C = 25°C, CC1312R_VDD = 3.3V, DC-DC enabled, 915 MHz, if nothing else is stated. All parameters were measured on the LAUNCHXL-CC1312R1 reference design [2] at an antenna connector with a 50 Ω load. An on-board PCB antenna was used in radiative measurements.

Table 7. Transmit Parameters – 915 MHz

Parameter	Condition	Typical	Unit
Max output power	At +14 dBm setting	14.0	dBm
Tx output power	At +10dBm setting	9.6	dBm
Harmonic emission	At +14 dBm Setting		dBm
	Conducted 2nd harmonic	-50.1	
	Conducted 3nd harmonic	-58.5	
	Conducted 4th harmonic	-59.7	
	At +10 dBm setting		
	Conducted 2nd harmonic	-46.1	
	Conducted 3nd harmonic	<-59.6	
	Conducted 4th harmonic	<-59.6	
Spurious emissions Out-of-band (FCC)	At +14 dBm setting, (used average detector)		dBm
	Conducted from 30 MHz to 88 MHz	<-57	
	Conducted from 88 MHz to 216 MHz	<-57	
	Conducted from 216 MHz to 960 MHz	-50.4	
	Conducted above 960 MHz	-55.1	

3.7 Typical Characteristics – Receive - 868 MHz

T_C = 25°C, CC1312R_VDD = 3.3 V, DC-DC enabled, f = 868 MHz, if nothing else is stated. All parameters were measured on the LAUNCHXL-CC1312R1 reference design [2] at an antenna connector with a 50 Ω load. An on-board PCB antenna was used in radiative measurements. Sensitivity limit is defined as 1% BER with 3 bytes packet length.

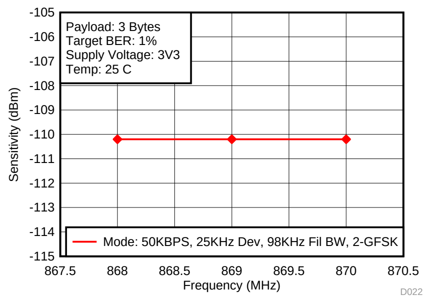

Figure 3. Rx Sensitivity vs Frequency at 50 KBPS – 868 MHz Band

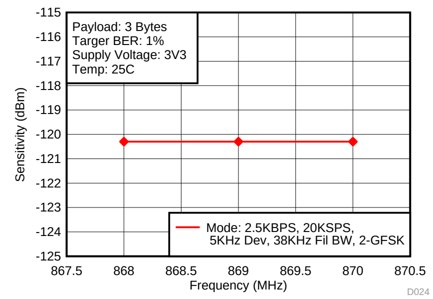

Figure 4. Rx Sensitivity vs Frequency in LRM – 868 MHz Band

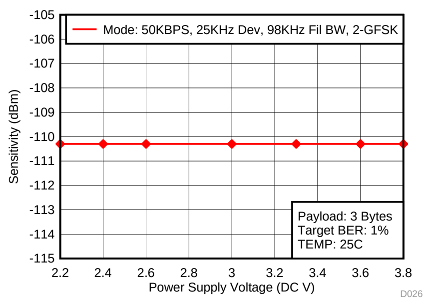

Figure 5. Rx Sensitivity vs Voltage at 50 KBPS – 868 MHz

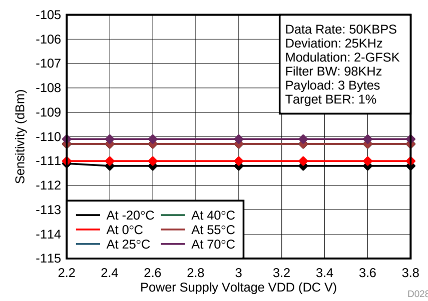

Figure 6. Rx Sensitivity vs Voltage vs Temperature – 868 MHz

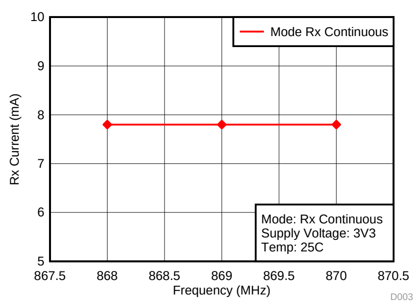

Figure 7. Rx Current vs Frequency in Rx Continuous Mode - 868 MHz Band

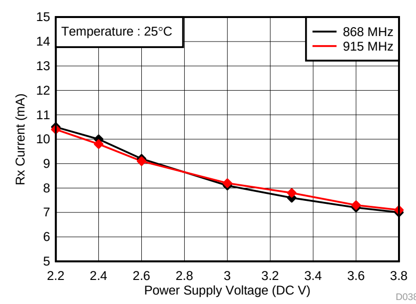

Figure 8. Rx Current vs Voltage in Rx Continuous Mode - 868 MHz

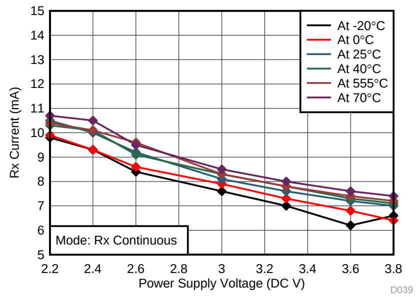

Figure 9. Rx Current vs Voltage vs Temperature in Rx Continuous Mode - 868 MHz

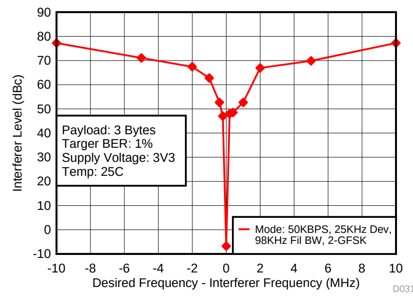

Figure 10. Rx Selectivity at 50 KBPS – 868 MHz

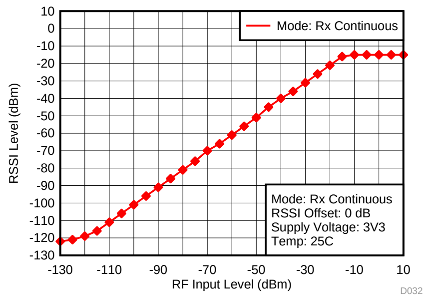

Figure 11. RSSI vs RF Input Level at 868 MHz

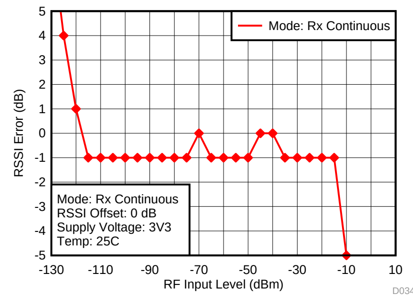

Figure 12. RSSI Error vs RF Input Level at 868 MHz

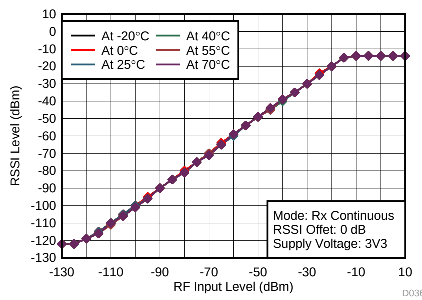

Figure 13. RSSI vs RF Input Level vs Temperature – 868 MHz

3.8 Typical Characteristics – Transmit - 868 MHz

T_C = 25°C, CC1312R_VDD = 3.3 V, DC-DC enabled, f = 868 MHz, if nothing else is stated. All parameters were measured on the LAUNCHXL-CC1312R1 reference design [2] at an antenna connector with a 50 Ω load. An on-board PCB antenna was used in radiative measurements.

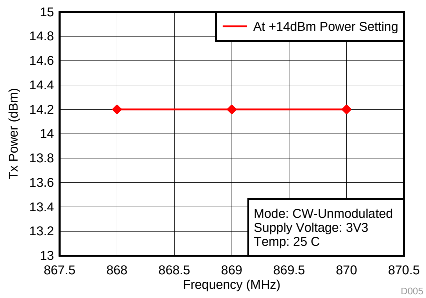

Figure 14. Tx Power vs Frequency – 868 MHz Band

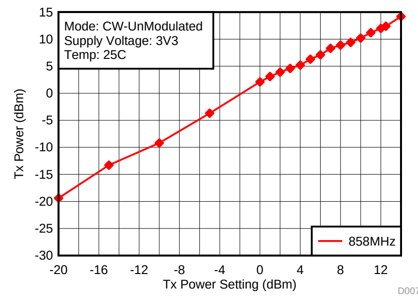

Figure 15. Tx Power vs Tx Setting – 868 MHz

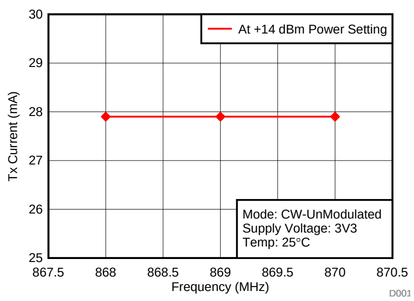

Figure 16. Tx Current vs Frequency – 868 MHz Band

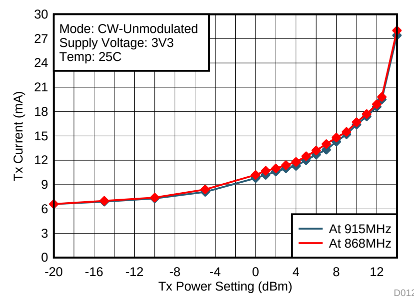

Figure 17. Tx Current vs Tx Power Setting – 868 MHz

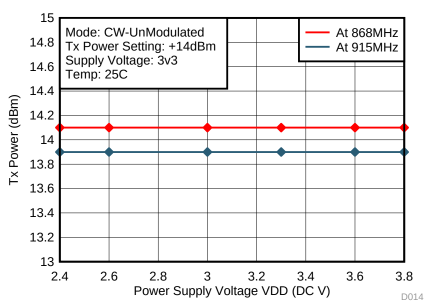

Figure 18. Tx Power vs Voltage at +14 dBm Setting – 868 MHz

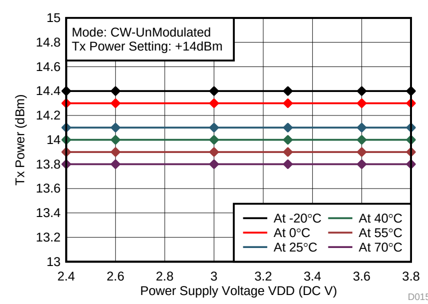

Figure 19. Tx Power vs Voltage vs Temperature at +14 dBm Setting – 868 MHz

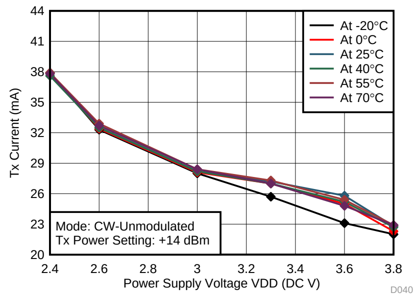

Figure 20. Tx Current vs Voltage vs Temperature at +14 dBm Setting – 868 MHz

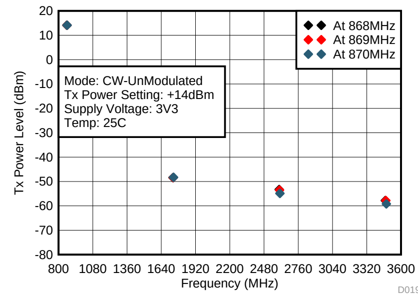

Figure 21. Harmonic Level at +14 dBm Setting – 868 MHz Band

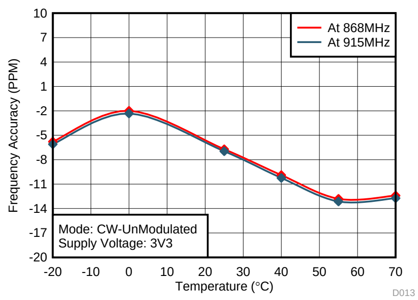

Figure 22. Tx Frequency Accuracy vs Temperature – 868 MHz

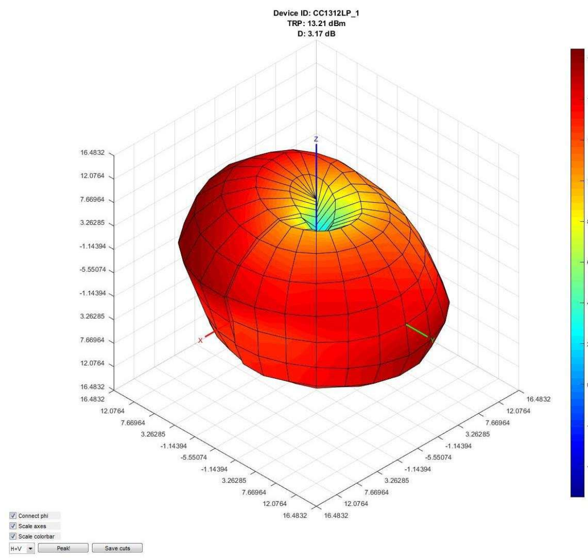

Figure 23. Antenna Radiation Pattern at +14 dBm Setting – 868.3 MHz

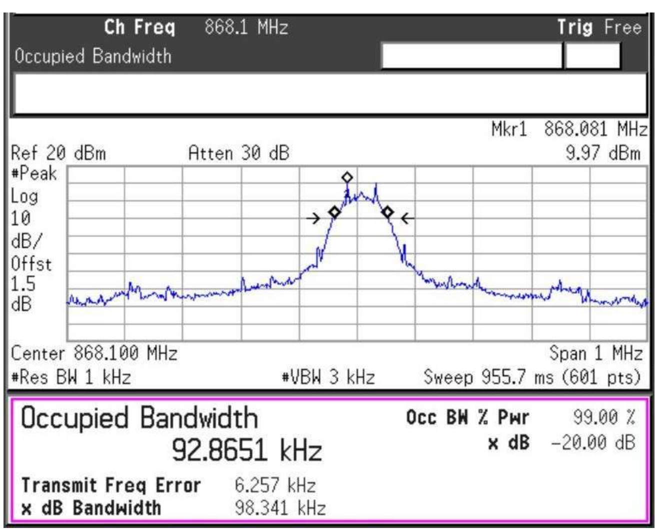

Figure 24. Tx Occupied Bandwidth at 50 KBPS at +14 dBm – 868 MHz

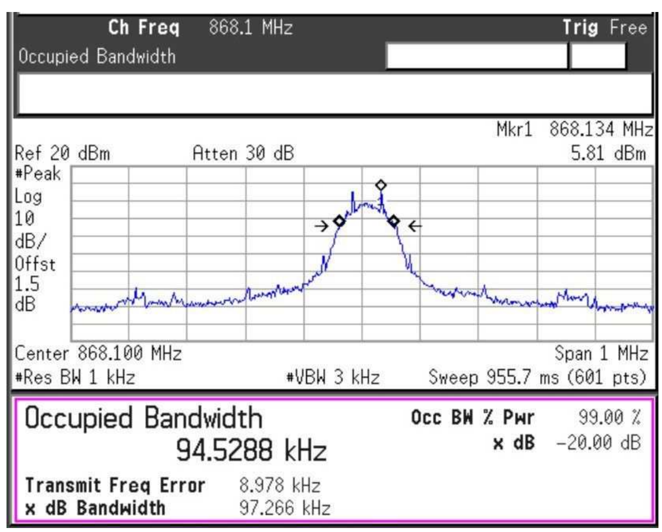

Figure 25. Tx Occupied Bandwidth at 50 KBPS at +10 dBm – 868 MHz

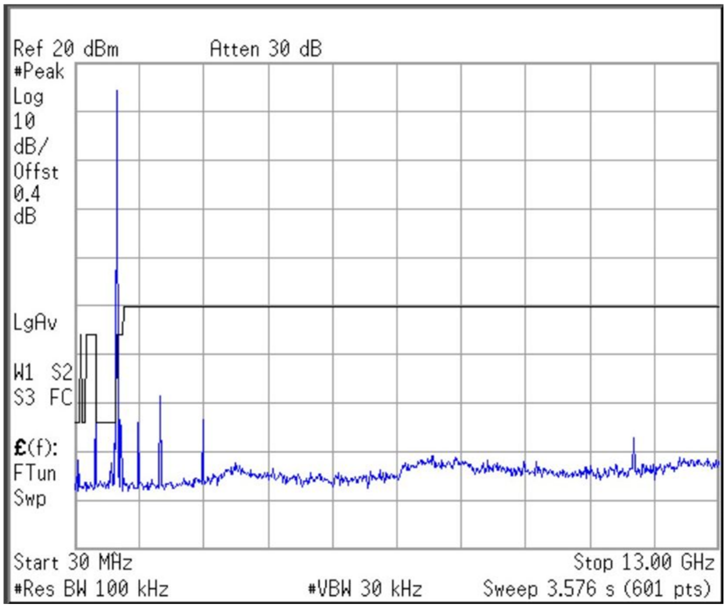

Figure 26. Tx Unwanted Emissions – Operating at 868 MHz - ETSI

3.9 Typical Characteristics – Receive - 915 MHz Band

T_C = 25°C, CC1312R_VDD = 3.3 V, DC-DC enabled, f = 915 MHz, if nothing else is stated. All parameters were measured on the LAUNCHXL-CC1312R1 reference design [2] at an antenna connector with a 50 Ω load. An on-board PCB antenna was used in radiative measurements. Sensitivity limit is defined as 1% BER with 3 bytes packet length.

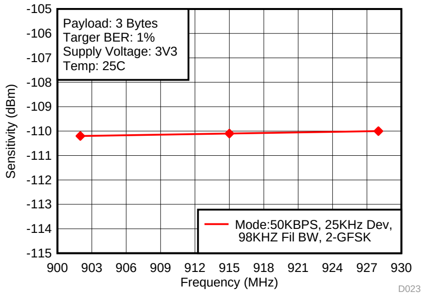

Figure 27. Rx Sensitivity vs Frequency at 50 KBPS – 915 MHz Band

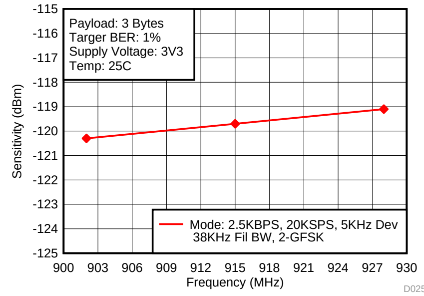

Figure 28. Rx Sensitivity vs Frequency in LRM – 915 MHz Band

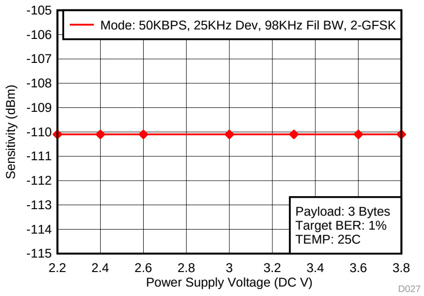

Figure 29. Rx Sensitivity vs Voltage at 50 KBPS – 915 MHz

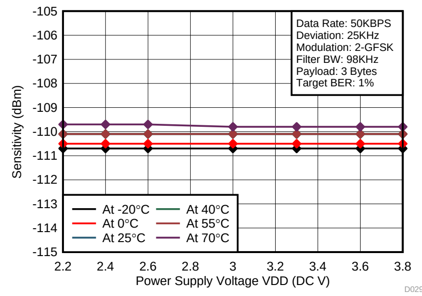

Figure 30. Rx Sensitivity vs Voltage vs Temperature – 915 MHz

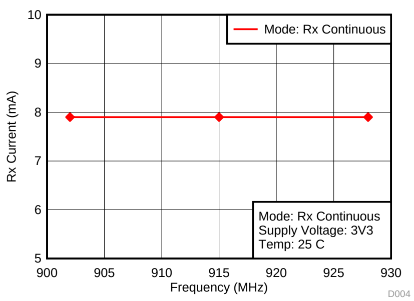

Figure 31. Rx Current vs Frequency - 915 MHz

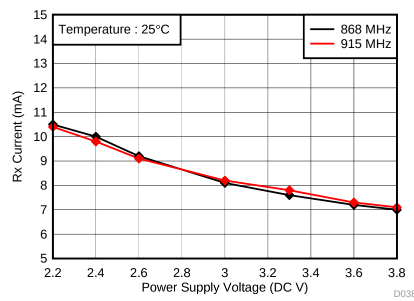

Figure 32. Rx Current vs Voltage in Rx Cont Mode - 915 MHz

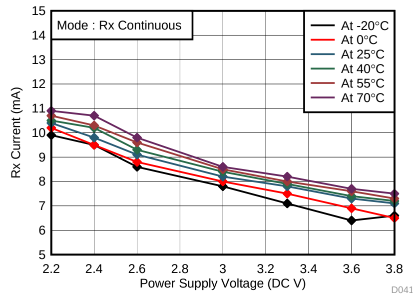

Figure 33. Rx Current vs Voltage vs Temperature in Rx Cont Mode - 915 MHz

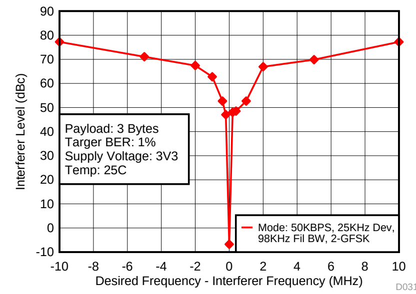

Figure 34. Rx Selectivity at 50 KBPS – 915 MHz

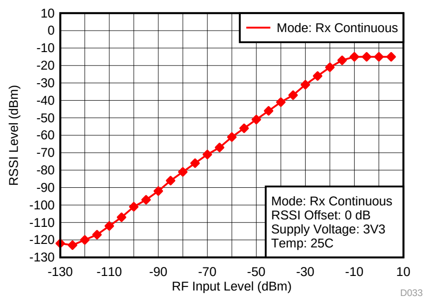

Figure 35. RSSI vs RF Input Level at 915 MHz

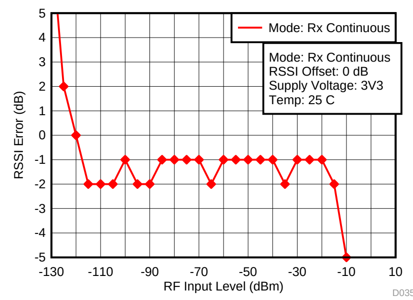

Figure 36. RSSI Error vs RF Input Level at 915 MHz

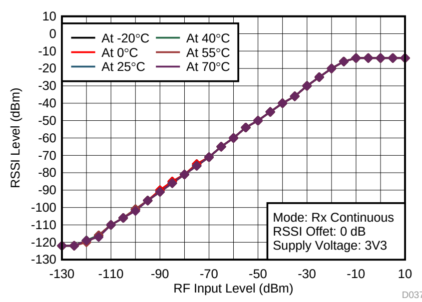

Figure 37. RSSI vs RF Input Level vs Temperature – 915 MHz

3.10 Typical Characteristics – Transmit -915 MHz Band

T_C = 25°C, CC1312R_VDD = 3.3 V, DC-DC enabled, f = 915 MHz, Tx power setting = 14 dBm, if nothing else is stated. All parameters were measured on the LAUNCHXL-CC1312R1 reference design [2] at an antenna connector with a 50 Ω load. An on-board PCB antenna was used in Radiative measurements.

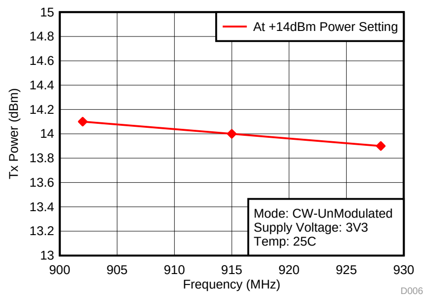

Figure 38. Tx Power vs Frequency - 915 MHz Band

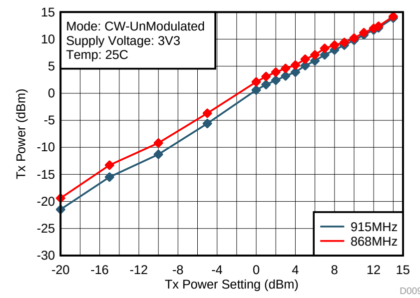

Figure 39. Tx Power vs Tx Power Setting - 915 MHz

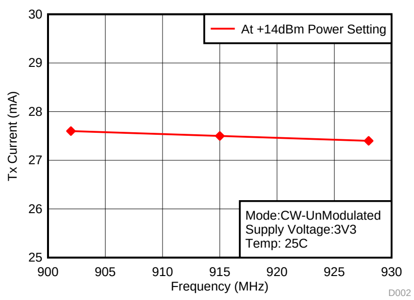

Figure 40. Tx Current vs Frequency - 915 MHz Band

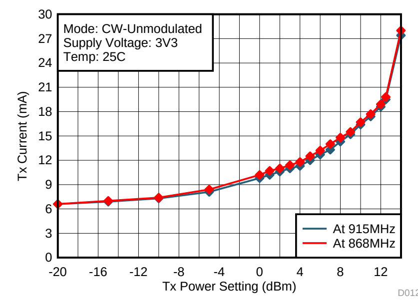

Figure 41. Tx Current vs Tx Power Setting - 915 MHz

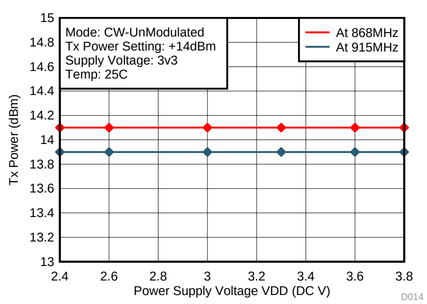

Figure 42. Tx Power vs PS Voltage at +14 dBm - 915 MHz

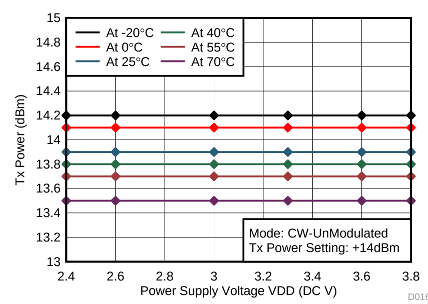

Figure 43. Tx Power vs PS Voltage vs Temperature - 915 MHz

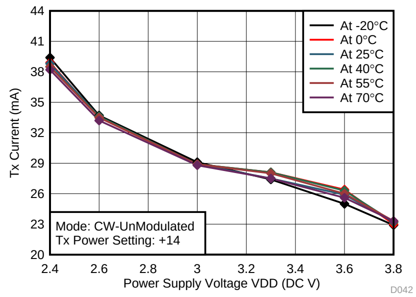

Figure 44. Tx Current vs PS Voltage vs Temperature - 915 MHz

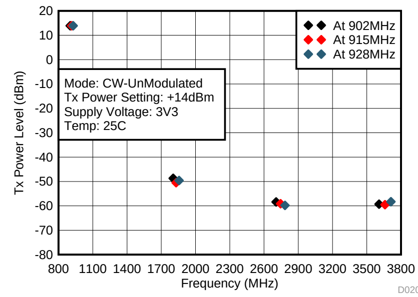

Figure 45. Harmonic Level at 14 dBm - 915 MHz Band

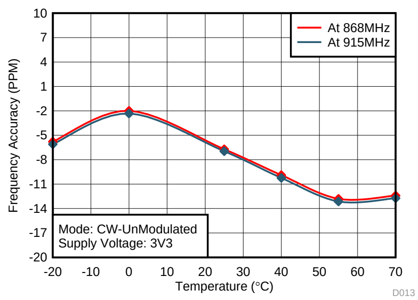

Figure 46. Tx Frequency Accuracy vs Temperature - 915 MHz

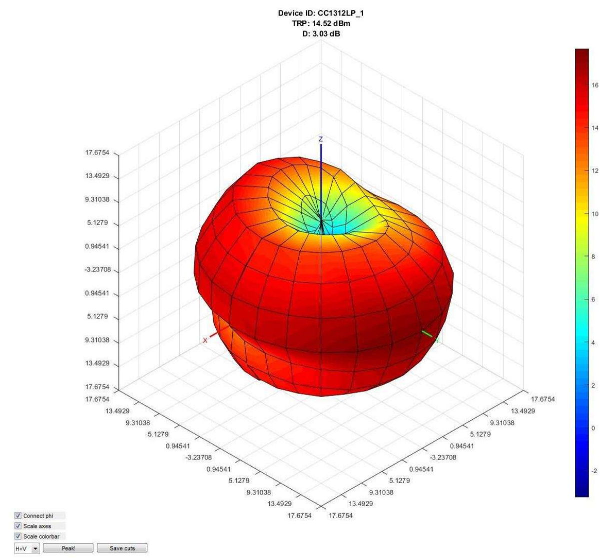

Figure 47. Antenna Radiation Pattern at +14 dBm Setting - 915 MHz

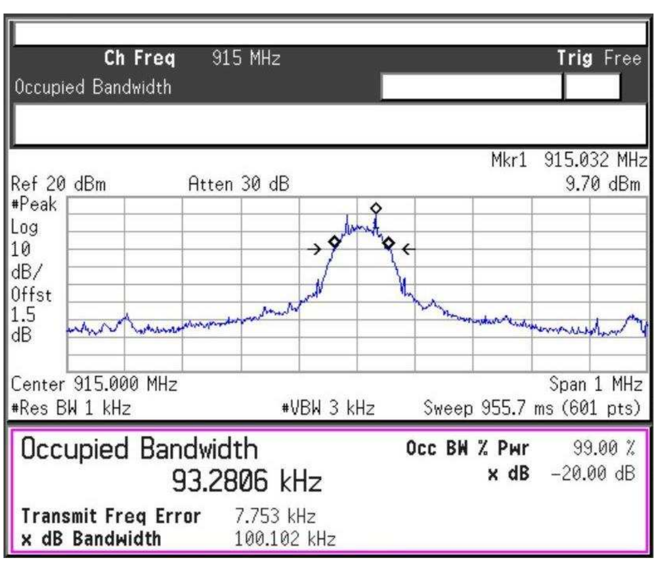

Figure 48. Tx Occupied Bandwidth at 50 KBPS at +14 dBm – 915 MHz

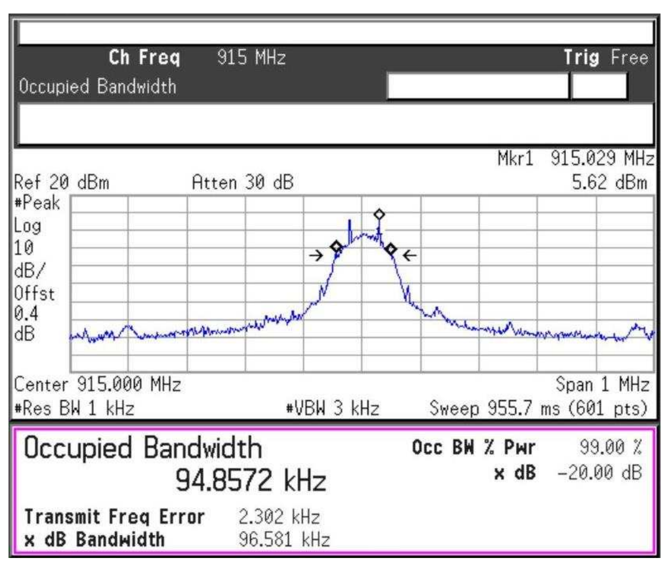

Figure 49. Tx Occupied Bandwidth at 50 KBPS at +10 dBm – 915 MHz

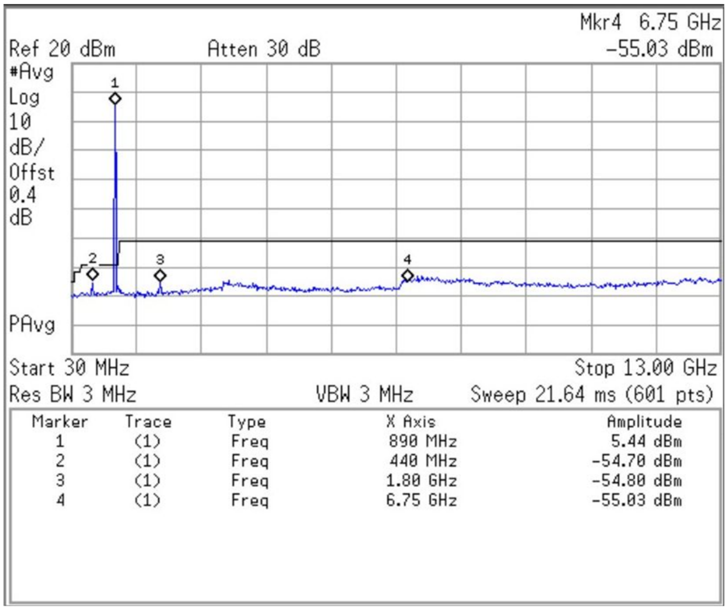

Figure 50. FCC - Tx Spurious Emissions – Conducted at 915 MHz

4 Hardware Details

Figure 51 shows the hardware details of the LAUNCHXL-CC1312R1 Launchpad [16]. For an Out of the box Demo and introduction, see the CC1312R quick start guide [4].

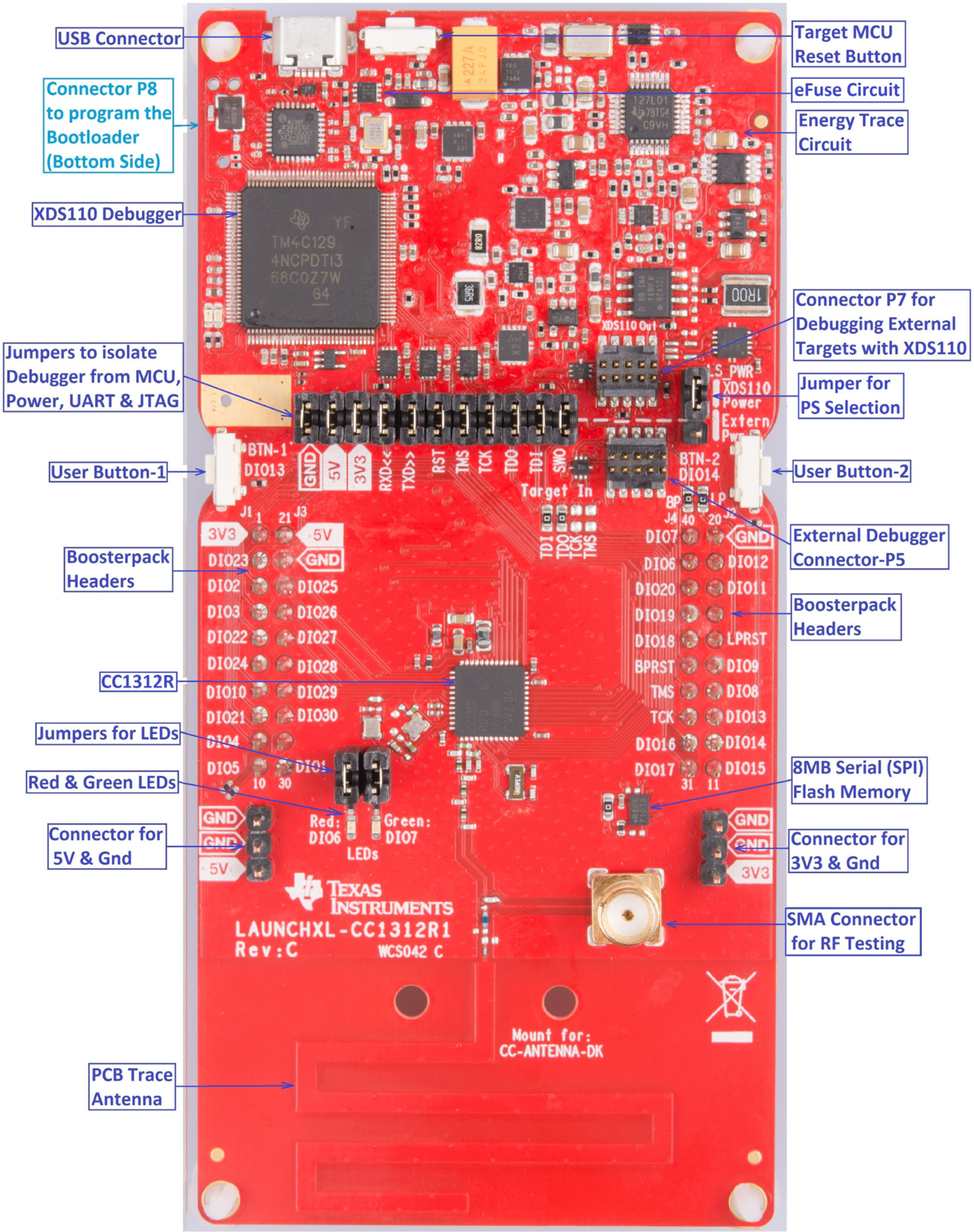

Figure 51. LAUNCHXL-CC1312R1 Launchpad Hardware Details

4.1 Power Supply Requirements

The LaunchPad LAUNCHXL-CC1312R1 [16] is designed to be powered from a USB-compliant power source, either a USB charger or a computer. When used this way, jumpers need to be mounted on the 3V3 position of the central jumper block. An LDO powered from the USB VBUS supply supplies 3.3 V to the XDS debugger, the CC1312R, and associated circuitry including the 3V3-marked pins for BoosterPacks.

4.2 USB Connector (J6)

The USB connector J6 can be used to power up from a USB-compliant power source, either a USB charger or a computer. This connector can also be used to interface with the computer to use with SamrtRF Studio7 application software [11] to control, test and verify the performance of the module.

4.3 Main Jumper Block (P4)

The main jumper block (P4) near to the XDS110 debugger of the board can be used to disconnect the upper section (XDS110 debugger) from the bottom section (CC1312R). The jumpers are mounted by default.

4.4 PS Selection - Jumper Block (P10)

The jumper block (P10), marked as VSENSE, can be used to select the source of power to the CC1312R and Level shifters. Usually, power is supplied from USB and a jumper is mounted in the position marked XDS110 power (factory default). If you want to power CC1312R from an external supply, move the jumper to the position marked Extern. Pwr, and connect the external supply to the 3V3 pin on P1. Also make sure to remove the 3V3 jumper from the main jumper block, P4. Make sure that the voltage applied stays within the supply range of the CC1312R.

4.5 XDS110 Debugger

TI's Tiva™ C series TM4C1294NCPDTT3R MCU chip [7] is used as XDS110 Debugger. The XDS110 is the in-circuit programmer/debugger of the CC1312R device. It also implements a 1MBPS UART to the USB functionality that enables the customer to develop code that uses a UART connection to the PC. The on-board XDS110 debugger can be used to debug external circuits, like a customer's prototype boards by using connector P7.

4.6 Debug Connectors (P5 and P7)

Debug connector P5, marked as CC1312R In, can be used to debug CC1312R with an external debugger like the XDS200, which has much higher performance, higher read and write speed when debugging and developing. This requires to remove all the jumpers on P4. Debug connector P7, marked XDS110 Out, can be used to debug external targets like a customer's prototype boards with XDS110. It is also required to remove all the jumpers on P4.

4.7 BoosterPack Headers (J1 and J2)

BoosterPack headers J1 and J2 can be used to plug-in BoosterPack modules to test and develop different applications. The same headers can be used to plug-in 430BOOST-SHARP96 LCD BoosterPack [6] to extend the display option to this module.

4.8 Reset Button

Reset button SW3, marked as RESET, can be used to reset the USB port of the Launchpad.

4.9 User Buttons

User buttons SW1 and SW2 are connected to the DIO13 and DIO14 lines on the CC1312R device. These buttons can be configured or programmed by the user for their requirements.

4.10 LEDs

Red and Green LEDs CR1 and CR2 are connected to DIO6 and DIO7 lines through the Jumper Header P6 on the CC1312R device. These LEDs can be configured or programmed by the user for their requirements. The jumpers should be mounted on P6 to control the LEDs from the CC1312R.

4.11 Power Supply Headers (P1 and P2)

Power supply header P1 is connected to 3.3V and P2 is connected to 5 V rails on the board through the jumpers on the main jumper block header P4. These headers can be used as a power source to power up the external boards, if the current requirement is within the limits of TPS79601 [8] for 3.3 V and USB power for 5 V. These headers can also be used to power-up the board from an external power supply. When used external power supply, the corresponding jumpers (3V3 and 5 V) on the main jumper block P4 must be removed.

4.12 Bootloader Program Connector (P8)

Bootloader program connector P8 is provided on the bottom side of the board. This connector can be interfaced with the 20-pin Arm JTAG connector on SmartRF06 evaluation board [9] to program a bootloader on the LaunchPad. 10-pin flat cable with Arm connector from TagConnect (TC2050-ARM20-10) is required to interface with SmartRF06 evaluation board

4.13 External Flash Memory

8 Mbit external serial peripheral interface (SPI) Flash memory chip, U4 is provided on the LaunchPad to extend more memory to the user.

4.14 RF Connector

For more information, see Section 5.3.

4.15 Energy Trace Circuit

EnergyTrace™ technology is an energy-based code analysis tool that measures and displays the application's energy profile and helps to optimize it for ultra-low power consumption.

The on-board EnergyTrace circuit allows real time monitoring of internal device states while user program code executes. EnergyTrace technology is available as part of TI's Code Composer Studio IDE. The minimum current which can be measurable by the current version of Energy trace circuit is limited by the noise in the circuit.

On the LaunchPad development kit, EnergyTrace technology measures the current that enters the target side of the LaunchPad development kit. This includes all BoosterPack plug-in modules plugged in, and anything else connected to the 3V3 power rail. For more information about the usage of Energy Trace circuit, see the *Meet the CC1312R Launchpad Development Kit* page [3].

4.16 eFuse Circuit

TI's TPS259530 (U47) used as an eFuse. It protects from Overvoltage, Overcurrent, short circuits, voltage surges, excessive inrush current and Over temperature. The eFuse constantly monitors the input supply to ensure that the load is powered up only when the voltage is at sufficient level. During the start-up condition, the device waits for the input supply to rise above a fixed threshold voltage of around 4.2 V to turn ON. The eFuse also provides overvoltage protection by clamping the output voltage to a predefined level of 5.3 V if the input voltage crosses beyond 5.5 V and up to 20 V maximum. This ensures the load is not exposed to high voltages on any overvoltage at the input supply (USB supply). As long as the an overvoltage condition is present on the input, the ouptput voltage will be clamped to 5.3 V. When the iput drops below the output clamp, the clamp releases the output voltage.

During the overvoltage clamp condition, there could be significant heat dissipation in the eFuse depending on the Vin-Vout voltage drop and the current through the eFuse leading to thermal shutdown if the condition persists for an extended period of time. In this case, the eFuse shuts down and remains in Latched-Off state until the board is power cycled. Output Over Load Current limit was set at 470 mA. For more information about eFuse, see [17].

5 Reference Design

The LAUNCHXL-CC1312R1 reference design [2] includes schematic, PCB Layout and complete bill of materials (BOM). The board layout greatly influences the RF performance of the CC1312R device. It is highly recommended to follow the reference design for optimum performance.

5.1 RF, Balun and Filtering

CC1312R has an RF differential port. A balun is required to transform the differential port in to a single ended 50 Ω port. Harmonic filter is provided for harmonic suppression.

5.2 Antenna and Matching

A PCB trace antenna is provided to cover both 868 MHz and 915 MHz bands.

5.3 RF Connector

SMA Connector J7 is provided in the design to facilitate the connection to the test equipment for test and measurement application for RF testing and as wells as to facilitate an external antenna connection. Remove C36 to disconnect the PCB tarce antenna and place it at C37 to use J7. Remove C24 to disconnect PCB trace antenna and place 0 Ω resistor at C67 to use P12 on the 2.4 GHz path.

5.4 Crystal Oscillator

A 48 MHz crystal is used in the design as a default. For the detailed specification of the crystal, see the CC1312R data sheet [1]. A 48 MHz TCXO circuit is also provided as an option (instead of using a 48 MHz Crystal) on the board. For details on how to connect TCXO to the CC1312R chip, see the schematic [2]. Also, note that the TCXO option must be selected in SmartRF Studio 7 to use TCXO. For TCXO details, see BOM [2].

5.5 PCB Layout Considerations

The LAUNCHXL-CC1312R1 reference design [2] uses a 1.6 mm (0.064”) 4-layer PCB solution. Note that the different layers have different thickness. It is recommended to follow the layer stack-up given in the LAUNCHXL-CC1312R1 reference design [2] to ensure optimum performance.

The top layer is used for components and signal routing, and the open areas are filled with metallization connected to ground using several vias. The area underneath the chip is used for grounding and must be well connected to the ground plane with multiple vias. Footprint recommendation for the CC1312R is provided in the CC1312R data sheet [1].

Layer two is a complete ground plane and is not used for any routing. This is done to ensure short return current paths. The low impedance of the ground plane prevents any unwanted signal coupling between any of the nodes that are decoupled to it.

Layer three is a mixed plane. The power supply and some of the digital lines are routed on this layer. Power supply planes were used for power supply routing. The open areas are filled with metallization connected to ground using several vias.

Layer four is used for routing, and the open areas are filled with metallization connected to ground using several vias

6 Regulatory Conformity

Ti declares that this product is in compliance with Directive 2014/53/EU. The compliance has been verified in the operating bands of 868 MHz to 868.6 MHz at +10dBm Tx Power setting. Should you choose to configure the EUT to operate outside of the test conditions, it should be operated inside a protected and controlled environment (such as, a shielded chamber). This evaluation board is only for development and not an end product. Developers and integrators that incorporate the chipset in any end products are responsible for obtaining applicable regulatory approvals for such end product.

7 References

1. *SimpleLink Sub-1 GHz CC1312R Wireless Microcontroller*
2. *CC1312 Launchpad (LAUNCHXL-CC1312R1) for 868/915MHz Reference Design*
3. *Meet the CC1312 Launchpad Development Kit*
4. *CC1312 LaunchPad Getting Started Guide*
5. *Sub-1 GHz and 2.4 GHz Antenna Kit for LaunchPad™ and SensorTag* product page
6. *Sharp Memory LCD BoosterPack* product page
7. *TM4C1294NCPDT (ACTIVE) IoT Enabled High Performance 32-Bit ARM® Cortex®-M4F Based MCU* product page
8. *TPS796xx Ultralow-Noise, High PSRR, Fast, RF, 1-A Low-Dropout Linear Regulators Data Sheet*
9. *SmartRF06 Evaluation Board* product page
10. *ISM-Band and Short Range Device Regulatory Compliance Overview*
11. *SmartRF Studio* product page
12. FCC rules (www.fcc.gov)
13. *ETSI Standard*
14. *CC-Antenna-DK2 and Antenna Measurements Summary*
15. *SimpleLink CC13x2 Software Development Kit* product page
16. *SimpleLink CC1312 Wireless MCU LaunchPad Development Kit* product page
17. TPS2595xx 2.7 V to 18 V, 4-A, 34-mΩ eFuse With Fast Overvoltage Protection Data Sheet

Revision History

NOTE: Page numbers for previous revisions may differ from page numbers in the current version.

Changes from A Revision (January 2018) to B Revision	Page
• Updated document with test results and the eFuse circuit.	1
• Updated many of the images in the document.	1
• Updates were made in Section 3.3.	6
• Updates were made in Section 3.4.	7
• Updates were made in Section 3.5.	8
• Updates were made in Section 3.6.	9
• Added new Section 4.16.	22
• Update was made in Section 5.4.	23
• Updated Section 7.	24

IMPORTANT NOTICE AND DISCLAIMER

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